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1.	Your reference	SH-58159 10 JUN 2002
2.	Patent application number *(The Patent Office will fill in this part)*	0213374.2 12JUN02 E725011-8 C03008 P01/7700 0.00-0213374.2
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	CITY UNIVERSITY OF HONG KONG TAT CHEE AVENUE KOWLOON TONG KOWLOON HONG KONG
	Patents ADP number *(if you know it)*	7338361001
	If the applicant is a corporate body, give the country/state of its incorporation	A HONG KONG COMPANY
4.	Title of the invention	PLANAR INDUCTIVE BATTERY CHARGER
5.	Name of your agent *(if you have one)*	LLOYD WISE, TREGEAR & CO
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	COMMONWEALTH HOUSE 1-19 NEW OXFORD STREET LONDON WC1A 1LW
	Patents ADP number *(if you know it)*	117001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications *(and if you know it)* the or each application number	Country Priority application number *(if you know it)* Date of filing *(day / month/ year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application Date of filing *(day / month/ year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Description	14
Claim(s)	5
Abstract	DML
Drawing(s)	12 + RV

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Priority documents	
Translation of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature

Date
10 June 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

STEVEN HOWE
020 7571 6200

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PLANAR INDUCTIVE BATTERY CHARGER

FIELD OF THE INVENTION

This invention relates to a battery charger, and in particular to a battery charger having a planar surface on which one or more battery powered devices may be placed for battery recharging through induction.

BACKGROUND OF THE INVENTION

Portable electronic equipment such as mobile phones, handheld computers, personal data assistants, and devices such as a wireless computer mouse, are normally powered by batteries. In many cases, rechargeable batteries are preferred because of environmental and economical concerns. The most common way to charge rechargeable batteries is to use a conventional charger, which normally consists of an AC-DC power supply (in case of using the ac mains) or a DC-DC power supply (in case of using a car battery). Conventional chargers normally use a cord (an electric cable for a physical electrical connection) to connect the charger circuit (a power supply) to the battery located in the portable electronic equipment. The basic schematic of the conventional battery charger is shown in Fig.1.

PRIOR ART

Inductive electronic chargers without direct physical electrical connection have been developed in some portable electronic equipment such as electric toothbrushes where because they are designed to be used in the bathroom in the vicinity of sinks and water, it is not safe to provide a conventional electrical connection. US6,356,049, US6301,128, US6,118,249, also all describe various forms of inductive chargers. These

inductive type chargers, however, use traditional transformer designs with windings wound around ferrite magnetic cores as shown in Fig.2. The main magnetic flux between the primary winding and secondary winding has to go through the magnetic core materials. Other contactless chargers proposed also use magnetic cores as the main structure for the coupled transformer windings.

A contactless charger using a single primary printed winding without any EMI shielding has been proposed by Choi et al in "A new contactless battery charger for portable telecommunications/computing electronics" ICCE International Conference on Consumer Electronics 2001 Pages 58-59. However, the magnetic flux distribution of a single spiral winding has a major problem of non-uniform magnetic flux distribution. As illustrated further below, the magnitude of the magnetic field in the centre of the core of a spiral winding is highest and decreases from the centre. This means that if the portable electronic device is not placed properly in the central region, the charging effect is not effective in this non-uniform field distribution. Furthermore, without proper EMI shielding, undesirable induced currents may flow in other metallic parts of the portable electronic equipment.

Also known in the prior art is a method of EMI shielding of a transformer winding as shown in Fig.3 using the combination of a ferrite plate and a copper sheet. This is described in US patent application 09/883,145 and in Tang et al, IEEE Power Electronics Specialists Conference, 2001, Volume 4, 2001 pp1919-1925, the contents of which are incorporated herein by reference.

SUMMARY OF THE INVENTION

According to the present invention there is provided a battery charger system comprising a charging module comprising a primary charging circuit and being formed

with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer, said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

In a preferred embodiment the primary winding is formed on a planar printed circuit board.

Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface. In this way the precise position and orientation of the electronic device on the charging surface is not critical. To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array.

In a preferred embodiment the primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface. This shielding may include a sheet of ferrite material, and more preferably also may further include a sheet of conductive material such as copper or aluminium

It is an advantage of the present invention that in preferred embodiments the planar charging surface may be large enough to receive two or more electronic devices, and the primary charging circuit is adapted to charge two or more devices simultaneously. In this way it is possible to charge more than one device simultaneously. For example the planar charging surface may be divided into a plurality of charging regions, which regions may be defined by providing a plurality of primary transformer windings arranged in a regular array and connecting the windings

in groups to define said charging regions. A further advantage of the present invention is that it enables the possibility of allowing a device to move over the charging surface while being charged at the same time. This possibility is particularly useful to a device which is designed to be moved such as a wireless computer mouse

Viewed from another aspect the present invention provides a battery charging system comprising a charging module comprising a primary charging circuit and being formed with a charging surface for receiving an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device.

Preferably the shielding comprises a sheet of ferrite material and a sheet of conductive material such as copper.

Preferably the winding is formed integrally with a back cover of said device.

An important aspect of the present invention is that it provides a battery charging system that employs a localised charging concept. In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged. In other words, when a device is placed on a planar charging surface that is greater in size than the device, energy is only transferred from that part of the planar charging surface that is directly beneath the device, and possibly also immediately adjacent areas that are still able to couple to the secondary coil.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Fig.1 is a schematic view of a conventional prior art battery charger with direct electrical connection,

Fig.2 is a schematic view of a conventional magnetic core-based transformer as used in prior art inductive battery charger systems,

Fig.3 is a schematic view of a planar transformer with shielding,

Figs.4(a)-(c) are (a) a perspective view of a battery charger system according to an embodiment of the present invention, (b) a view similar to (a) but showing the structure of the primary charging system, and (c) a view similar to (a) and (b) but showing the top cover removed for clarity,

Figs.5(a) & (b) show the structure of the primary charger with the top cover removed for clarity, and in Fig.5(a) with the structure shown in exploded view,

Figs.6(a) & (b) show (a) a single spiral PCB winding, and (b) the measured magnetic field distribution of a single spiral winding,

Figs.7(a) & (b) illustrate the use of a magnetic core to control magnetic field distribution,

Fig.8 shows an embodiment of the invention in which a plurality of primary windings are arranged in an array structure,

Figs.9(a) & (b) shows (a) a 4 x 4 primary winding array, and (b) the resulting magnetic field distribution,

Figs.10(a)-(c) illustrate an embodiment of the invention in which primary windings are arranged in groups with Fig.10(c) showing the equivalent circuit,

Fig.11 shows an example of the back cover of an electronic device desig[...] be recharged using an embodiment of the present invention,

Figs.12(a)-(d) show exploded views of the back cover of Fig.11,

Figs.13(a) & (b) show views of a watch that may be recharged in accordance with an embodiment of the invention, and

Fig.14 shows a charging module in accordance with an alternative embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described in respect of a preferred embodiment in the form of an inductive battery charger for portable electronic equipment such as mobile phones, handheld computers and personal digital assistants (PDA), and devices such as a wireless computer mouse.

Referring firstly to Fig.4, the inductive charger system comprises two modules, a power delivering charger module that contains the primary circuit of a planar isolation transformer and a secondary circuit that is located in the portable electronic equipment to be charged. In this embodiment of the invention, the charger circuit is located within a housing 1 that is formed with a flat charging surface 2. The secondary circuit is formed in the portable equipment to be charged (in this example a mobile phone 3) and the equipment is formed with at least one planar surface. As will be seen from the following description the equipment is charged simply by placing the equipment on the surface so that the planar surface on the equipment is brought into contact with the flat charging surface 2. It is a particularly preferred aspect of the present invention that the equipment to be charged does not have to be positioned on the charging surface in any special orientation. Furthermore, in preferred embodiments

of the invention two or more mobile devices may be charged simultaneously on the same charging surface, and/or a device that is designed to be moved (such as a wireless computer mouse) can be charged while being moved over the charging surface (which could be integrated into a computer mouse pad). It will also be seen from the following description that the energy transfer is "localised" in the sense that energy is only transferred from the charging surface to the device from that part of the charging surface that is directly beneath the device (and possibly to a lesser extent regions adjacent thereto).

Referring in particular to Fig.4(b) the primary charging module comprises a printed circuit board 4 formed with at least one spiral conductive track formed thereon as a primary winding. It will be understood, however, that the primary winding need not necessarily be formed on a PCB and could be formed separately. Preferably, as will be described further below, there are in fact a plurality of such spiral tracks disposed in an array as shown in Fig.4(c). Beneath the PCB 4 (ie the side of the PCB away from the charging surface) is provided EMI shielding comprising firstly a ferrite sheet 5 adjacent the PCB 4, and then a conductive sheet 6 which in this example may be a copper sheet. Beneath the copper sheet 6 may be provided any suitable form of substrate material 7, eg a plastics material. Above the PCB 4 may be provided a sheet of insulating material 8 which forms the charging surface. Preferably the PCB 4, the EMI shielding sheets 5,6, the substrate 7 and the insulating cover sheet 8 may also be generally the same size and shape, for example rectangular, so as to form the primary charging module with the charging surface being large enough to accommodate at least one, and more preferably two or more, devices to be charged. Figs.5(a) and (b) also show the structure of the charging module without the cover sheet and without any devices to be charged thereon for the sake of clarity.

As shown in Fig.4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings. The secondary winding is also planar and is located in the portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment. The rectified DC voltage is applied to the battery via mechanical contacts provided in an integrated back cover as will be described further below. No physical electrical connection between the primary charger circuit and the portable electronic equipment is needed.

The primary charger circuit has (1) a switched mode power electronic circuit, (2) the primary side of a planar transformer that consists of a group of primary windings connected in series or in parallel or a combination of both, (3) an EMI shield and (4) a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The schematic of the primary charger system is shown in Fig.5 without the insulating cover.

The battery charging system can be powered by AC or DC power sources. If the power supply is the AC mains, the switched mode power electronic circuit should perform a low-frequency (50 or 60Hz) AC to DC power conversion and then DC to high-frequency (typically in the range from 20kHz to 10MHz) AC power conversion. This high-frequency AC voltage will feed the primary planar windings of the primary charger circuit. If the power supply is a battery (e.g. a car battery), the switched mode power supply should perform a DC to high-frequency AC power conversion. The high-frequency voltage is fed to the primary windings of the planar transformer.

Preferably, the charger should be able to charge one or more than one items of portable electronic equipment at the same time. In order to achieve such a function, the

AC magnetic flux experienced by each item of portable equipment placed on the charging surface should be as even as possible. A standard planar spiral winding as shown in Fig.6(a) is not suitable to meet this requirement because its flux distribution is not uniform as shown in Fig.6(b) when the winding is excited by an AC power source. The reason for such non-uniform magnetic flux distribution is that the number of turns in the central region of the single spiral winding is largest. As the magnitude of the magnetic flux is proportional to the product of the number of turn and the current in the winding, the magnetic flux is highest in the centre of the winding.

One method to ensure uniform magnetic flux distribution is to use a concentric primary winding with a planar magnetic core as shown in Fig.7(a). This magnetic core-based approach allows the magnetic flux to concentrate inside the core and typical magnetic flux distribution is shown in Fig.7(b). In general, the flat charging interface surface of the primary charger should be larger than the total area of the portable electronic equipment.

In order to ensure that more than one item of portable electronic equipment can be placed on the flat charging surface and charged simultaneously, a second and more preferred method proposed is to ensure that the magnetic flux distribution experienced by each items of portable electronic equipment is as uniform as possible. This method can be realized by using a "distributed" primary planar transformer winding array structure as shown in Fig.8. This planar winding array consists of many printed spiral windings formed on the PCB. These printed spiral windings can be hexagonal, circular, square or rectangular spirals, and can be connected in series, in parallel or a combination of both to the high-frequency AC voltage generated in the power supply in the primary charger circuit. The array should comprises relatively closely spaced coils

so as to be able to generate the required near-uniform magnetic flux distribution, as an array of widely spaced apart coils may not generate such a near-uniform field.

Fig.9(a) shows a practical example with the transformer winding array connected in series so that all the fluxes created in the windings point to the same direction. Fig.9(b) show the measured flux distribution of one planar transformer when the windings in the transformer array are connected in series. This measurement confirms the near uniform magnetic flux distribution of the array structure. Comparison of Fig.6(b) and Fig.9(b) confirms the improvement of the uniform magnetic field distribution using the transformer array structure. In addition, this transformer array structure provides for the possibility of multiple primary transformer windings being provided for localized charging as will now be explained.

The primary transformer windings can also take the form of a combination of series and parallel connections if desired. Such an arrangement allows the charging surface to be divided into various charging regions to cater for different sizes of the secondary windings inside the portable electronic equipment. Fig.10(a) illustrates this localized charging zone principle. Assume that the transformer array is divided into 4 zones (A, B, C, and D). The transformer windings within each zone are connected in series to form one primary winding group with the distributed magnetic flux feature. There will be four primary windings in the equivalent circuit as shown in Fig.10(c). If the portable electronic equipment is placed on Zones A and B as shown in Fig.10(b), the equivalent electrical circuit is shown in Fig.10(c). Only the parallel primary transformer winding groups for Zones A and B are loaded because they can sense a nearby secondary winding circuit in the portable electronic equipment. Therefore, they will generate magnetic flux in Zones A and B. Primary transformer windings C and D are not loaded because they have no secondary transformer circuit close to them and

their equivalent secondary circuits are simply an open-circuit (Fig.10(c)). As a result, power transfer between the primary charger circuit and the secondary windings inside the portable electronic equipment takes place basically through the coupled regions (areas) of the charging interface surface covered by the portable electronic equipment. The non-covered area of the charging surface will transfer virtually no energy. This special design avoids unnecessary electromagnetic interference. A further advantage of this localised energy transfer concept, is that it enables a movable device (such as a wireless computer mouse) to be continually charged as it moves over the charging surface. In the case of a wireless computer mouse, for example, the primary charging circuit could be integrated into a mousepad and the mouse may be charged as it moves over the mousepad.

The back cover of the portable electronic equipment is a detachable back cover that covers the battery and which may be removed when the battery is replaced. In preferred embodiments of the present invention, this back cover has a built-in secondary planar transformer winding, a diode rectifier circuit and preferably a thin EMI shield as shown in Fig.12(b) & (c). When the back cover side of the portable equipment is placed near the flat charging surface of the primary charger circuit, this secondary winding couples the energy from the nearby primary transformer winding or windings. The rectifier circuit rectifies the coupled AC voltage into a DC voltage for charging the battery. This rectifier circuit also prevents the battery from discharging into the secondary winding. In order to avoid induced circuit from circulating in other metal parts inside portable electronic circuit, it is preferable to include a thin EMI shield as part of the integrated back cover structure as shown in Fig.12. This EMI shield can be a thin piece of ferrite material (such as a flexible ferrite sheet developed

by Siemens) or ferrite sheets, or more preferably a combination of a ferrite sheet and then a thin copper sheet.

It will thus be seen that, at least in its preferred forms, the present invention provides a new planar inductive battery charger for portable electronic equipment such as mobile phones, handheld computers, personal data assistant (PDA) and electronic watches, and wireless computer mice. The inductive charger system consists of two modules, including (1) a power delivering charger circuit that contains the primary circuit of a planar isolation transformer and a flat charging surface and (2) a separate secondary transformer circuit that consists of a printed winding, a rectifier and preferably a thin EMI shield and which is located in the portable electronic equipment to be charged.

An advantage of the present invention, at least in preferred forms, is that the primary charger circuit system has the primary side of a planar transformer and a flat interface surface on which one or more portable electronic devices can be placed and charged simultaneously. The secondary circuit can be integrated into the back cover of the portable electronic device or separately placed inside the electronic device. The invention also extends to a back cover design with an in-built secondary circuit for the portable equipment. The secondary winding of the planar transformer can be EMI shielded and integrated into the back cover adjacent to the battery in the portable electronic device. As long as the back cover sides of the portable electronic device are placed on the charger surface, one or more portable electronic devices can be charged simultaneously, regardless of their orientations.

Figs.13(a) and (b) show how an embodiment of the invention may be used to recharge a watch battery. A watch is formed with a basic watch mechanism 20, which is powered by a rechargeable battery 21. The watch mechanism is shielded from

electrical interference in the charging process by an EMI shield consisting of, for example, a copper sheet 22 and a ferrite sheet 23 (with the copper sheet closer to the watch mechanism than the ferrite sheet). The other side of the EMI shield is provided a planar coreless transformer secondary winding 24 formed with electrical contacts for connection to the battery 21 and with a rectifier circuit to prevent discharge of the battery. Finally, the watch structure is completed by the provision of a planar back cover 25 formed of non-metallic material. It will be understood that the watch battery may be recharged by placing the watch on the charging surface of a battery charging system as described in the above embodiments such that the back cover 25 lies flat on the planar charging surface. Electrical energy is then coupled from the primary winding(s) in the battery charging module to the secondary winding in the watch and then to the rechargeable battery.

In the embodiments described above the charging module is formed as a single integral unit (as shown for example in Figs.4 and 5). However, in some situations it may be desirable to separate the electronic charging circuit from the planar charging surface. This possibility is shown in Fig.14 in which the electronic charging circuit 30 is connected by a cable 31 to the charging surface 32. The charging surface 32 includes an insulating top cover, the planar primary windings printed on a PCB, and a bottom EMI shield formed of ferrite and a conductive sheet such as copper. This embodiment has the advantage that the charging surface is relatively thin, and therefore may be useful for example when the device to be charged is a wireless computer mouse because the charging surface can double as a mousepad as well as a charging surface.

The present invention, at least in preferred forms, provides a new charging system allows more than one piece of equipment to be charged simultaneously, and

regardless of their orientations on the charging surface, and allows a movable device to be charged while it moves over the charging surface.

CLAIMS

1. A battery charger system comprising a charging module comprising a primary charging circuit and being formed with a planar charging surface adapted to receive an electronic device to be charged, wherein said primary charging circuit includes the primary winding of a transformer, said primary winding being substantially parallel to said planar charging surface, wherein said primary winding is provided with electromagnetic shielding on the side of said winding opposite from said planar charging surface, and wherein said electronic device is formed with a secondary winding.

2. A battery charger system as claimed in claim 1 wherein said transformer primary winding is formed on a printed circuit board.

3. A battery charging system as claimed in claim 1 wherein the magnetic flux generated by said primary winding is substantially uniform over at least a major part of said planar charging surface.

4. A battery charging system as claimed in claim 1 wherein said charging module comprises a plurality of primary windings.

5. A battery charging system as claimed in claim 4 wherein said primary windings are disposed in a regular array.

6. A battery charging system as claimed in claim 5 wherein said primary windings are hexagonal, circular, rectangular, square or polygonal in shape.

7. A battery charger system as claimed in claim 1 wherein said shielding includes a sheet of ferrite material.

8. A battery charging system as claimed in claim 7 wherein said shielding further includes a second sheet of conductive material.

9. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to receive two or more electronic devices, and wherein said primary charging circuit is adapted to charge two or more devices simultaneously.

10. A battery charging system as claimed in claim 9 wherein said planar charging surface is divided into a plurality of charging regions.

11. A battery charging system as claimed in claim 10 wherein said primary charging circuit comprises a plurality of primary transformer windings arranged in a regular array and wherein said windings are connected in groups to define said charging regions.

12. A battery charging system as claimed in claim 1 wherein said primary charging circuit comprises an array of primary windings, and wherein when a device is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

13. A battery charging system as claimed in claim 1 wherein said planar charging surface is large enough to enable a said device to be moved over said charging surface while being charged.

14. A battery charging system comprising a charging module comprising a primary charging circuit and being formed with a charging surface for receiving an electronic device to be charged, wherein said charging module comprises a plurality of transformer primary windings arranged in a regular array.

15. A battery charging system as claimed in claim 14 wherein when an electronic device to be charged is placed on said charging surface charging energy is transferred to said device from only those primary windings closely adjacent to said device.

16. A battery charging system as claimed in claim 14 wherein said transformer primary windings are connected to each other in series and/or in parallel.

17. A battery charging system as claimed in claim 14 wherein said primary transformer windings are planar and substantially parallel to a planar charging surface.

18. A battery charging system as claimed in claim 17 wherein said primary windings are formed on a printed circuit board.

19. A battery charging system as claimed in claim 17 wherein electromagnetic shielding is provided on the side of said primary windings opposite from said planar charging surface.

20. A battery charging system as claimed in claim 19 wherein said shielding comprises a sheet of ferrite material.

21. A battery charging system as claimed in claim 20 wherein said shielding further comprises a second sheet of conductive material.

22. A battery charging system as claimed in claim 14 wherein said charging surface is large enough to allow two or more devices to be charged thereon simultaneously.

23. A battery charging system as claimed in claim 14 wherein said charging surface is large enough to allow a device to be moved over the charging surface while being charged.

24. A battery powered portable electronic device comprising a rechargeable battery, and wherein said device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between said winding and the major electronic components of said device.

25. An electronic device as claimed in claim 24 wherein said shielding comprises a sheet of ferrite material and a sheet of conductive material.

26. An electronic device as claimed in claim 24 wherein said winding is formed integrally with a back cover of said device.

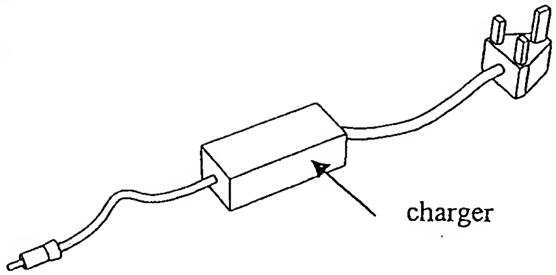


FIG.1 (PRIOR ART)

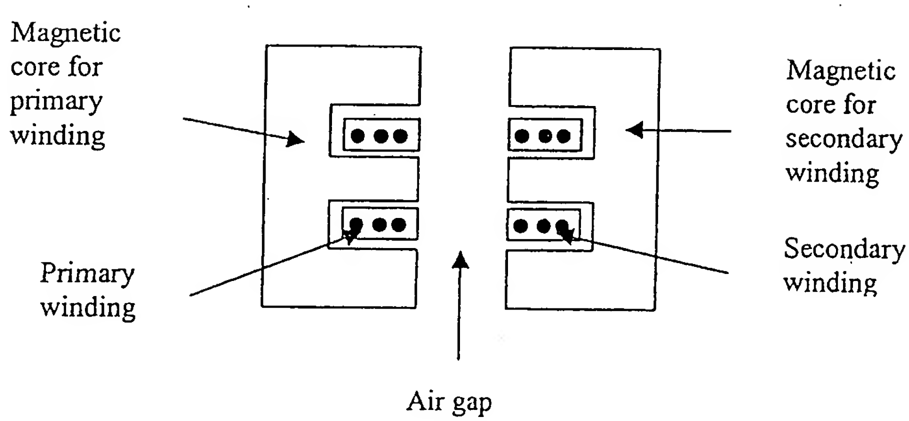


FIG.2 (PRIOR ART)

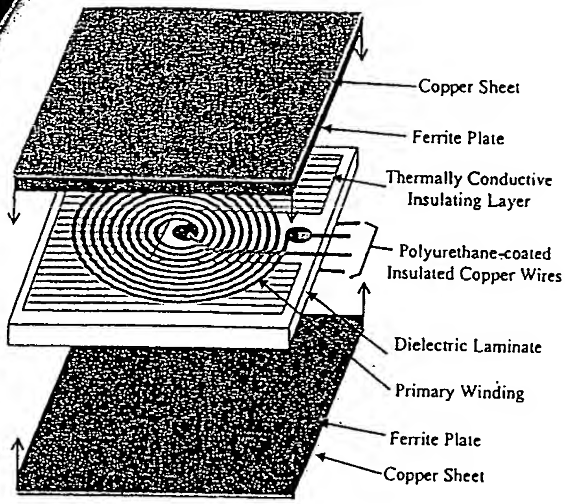


FIG.3 (PRIOR ART)

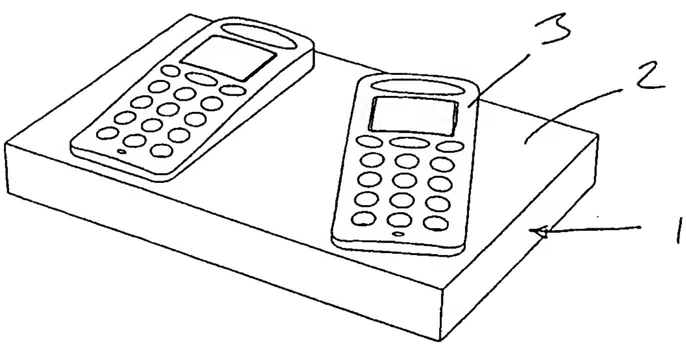


FIG.4 (a)

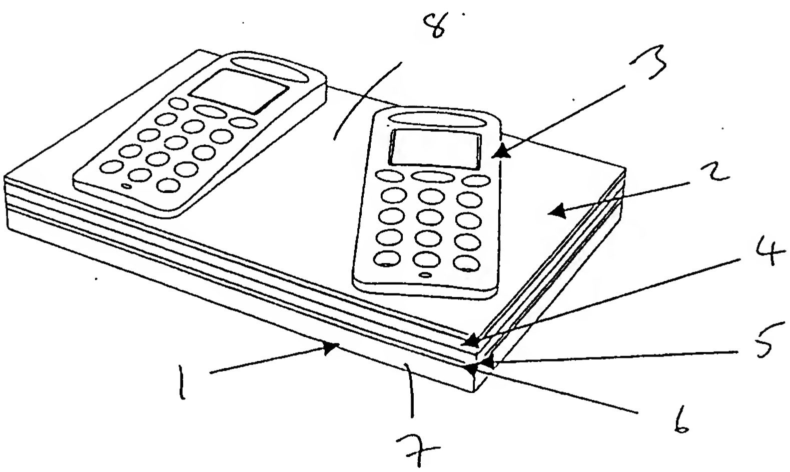


FIG.4 (b)

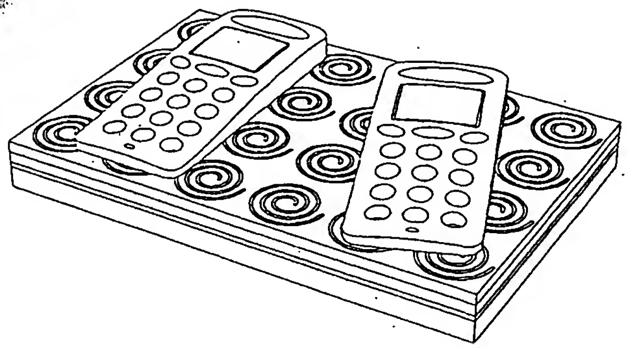


FIG.4 (c)

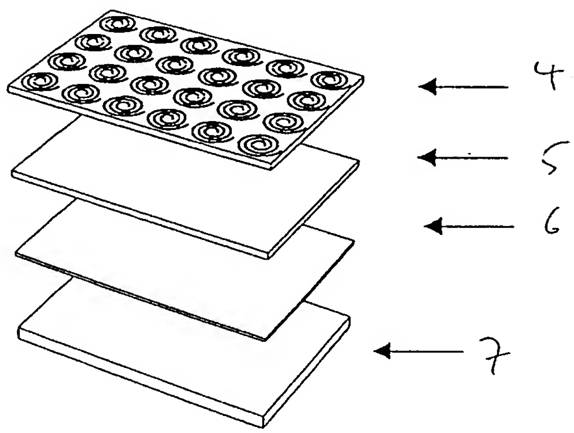


FIG.5(a)

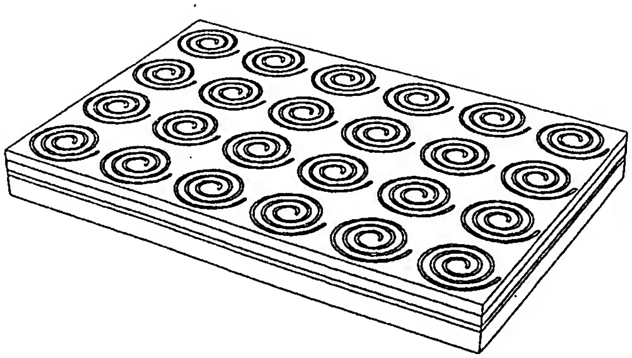


FIG.5(b)

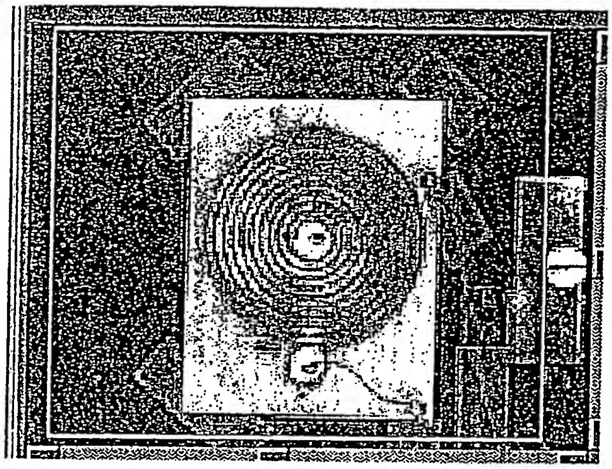
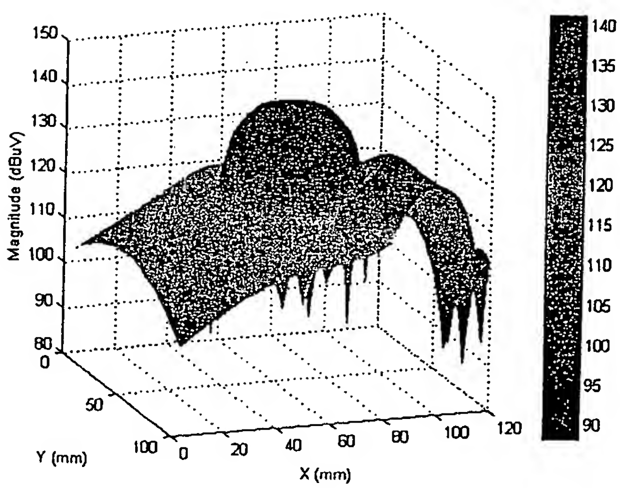


FIG.6(a)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X (mm)
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95
90

FIG.6(b)

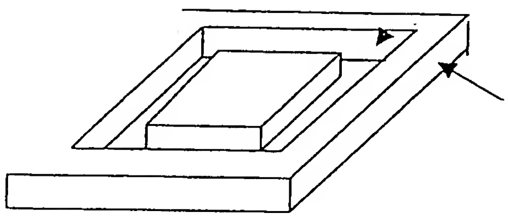

FIG.7(a)

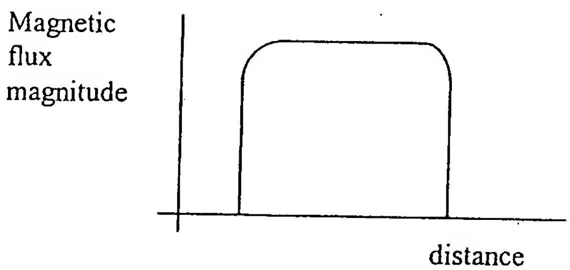

FIG.7(b)

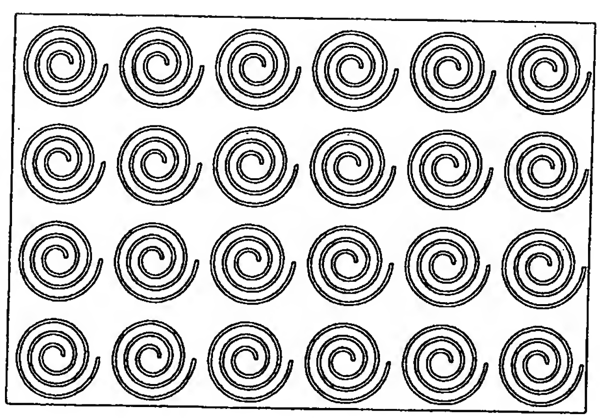

FIG.8

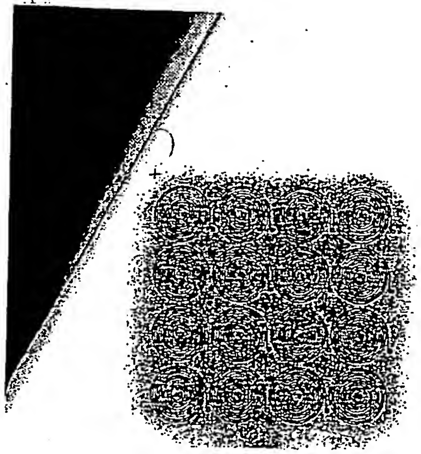

FIG.9(a)

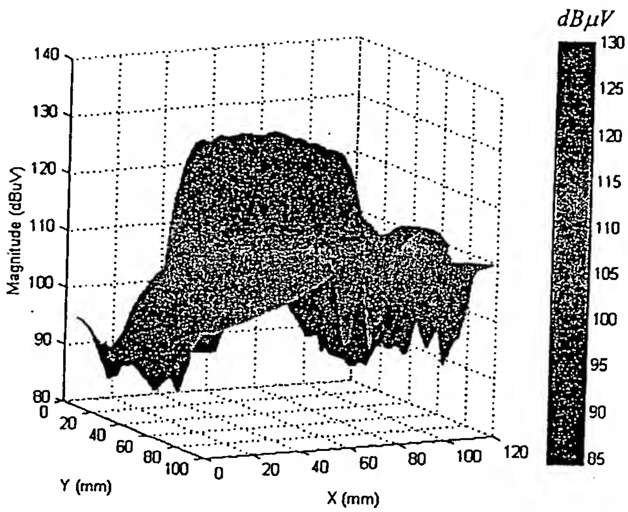
dBμV
Magnitude (dBuV)
Y (mm)
X (mm)
140
130
120
110
100
90
80
0
20
40
60
80
100
120
125
115
105
95
85

FIG.9(b)

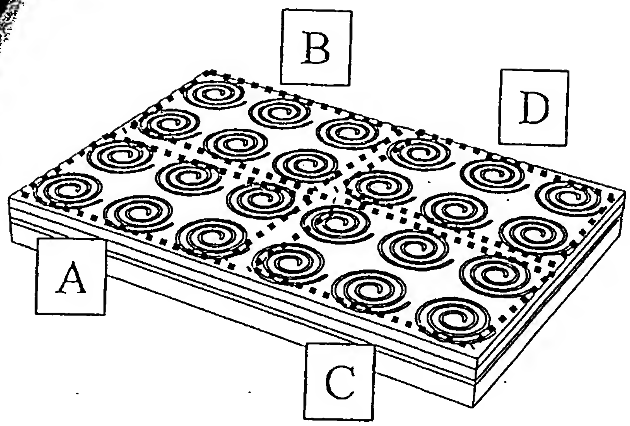

FIG.10(a)

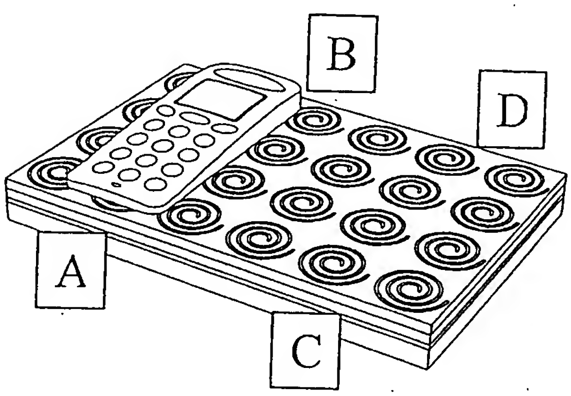

FIG.10(b)

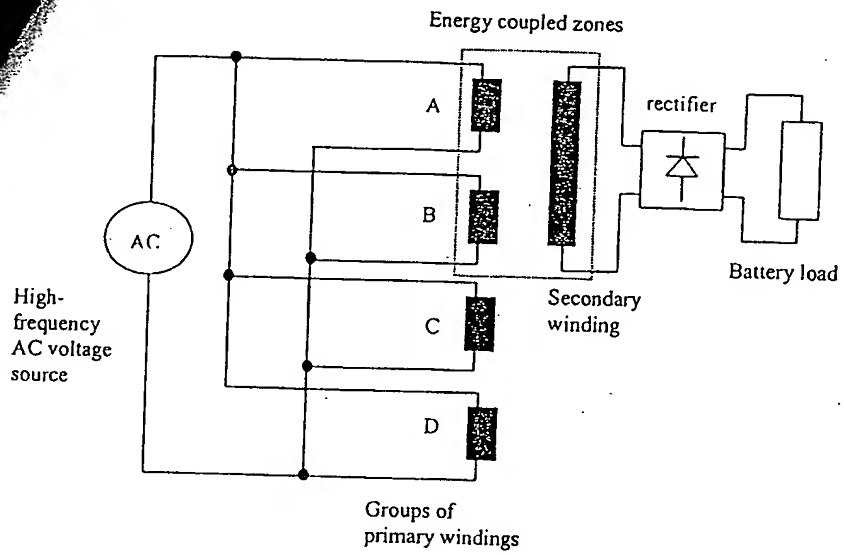

FIG.10(c)

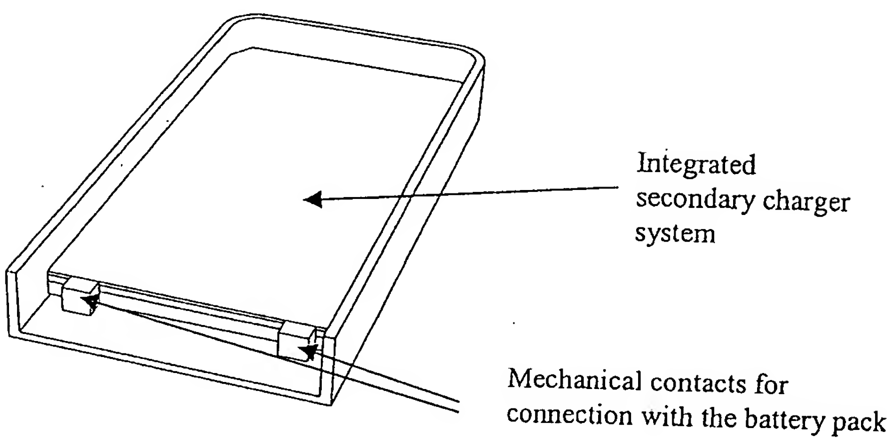

FIG.11

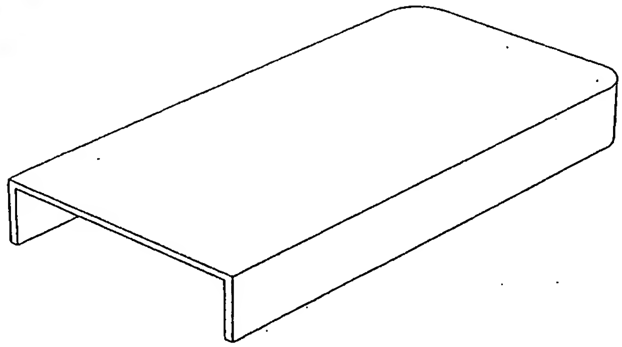

FIG.12(a)

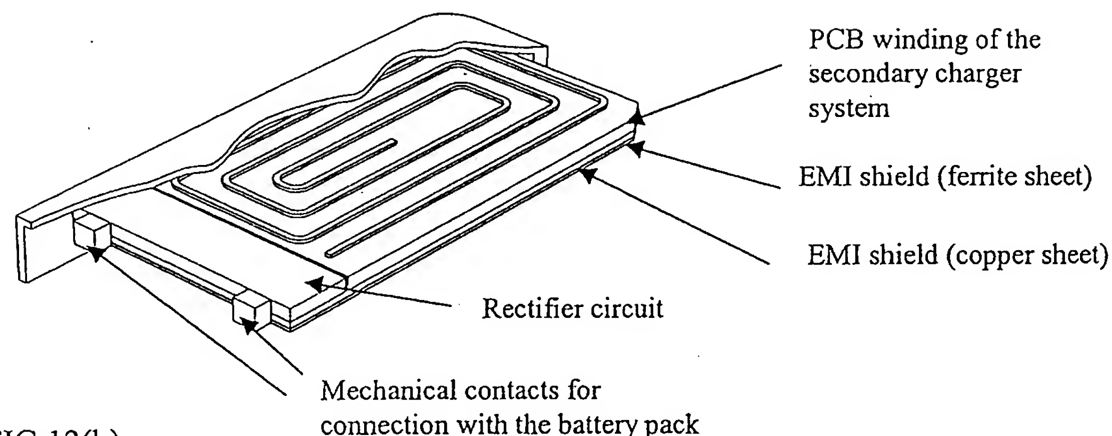

FIG.12(b)

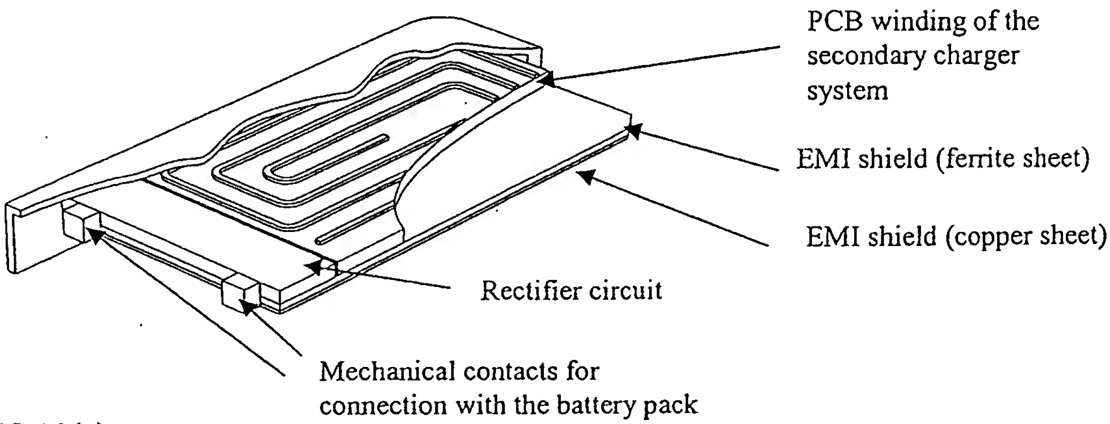

FIG.12(c)

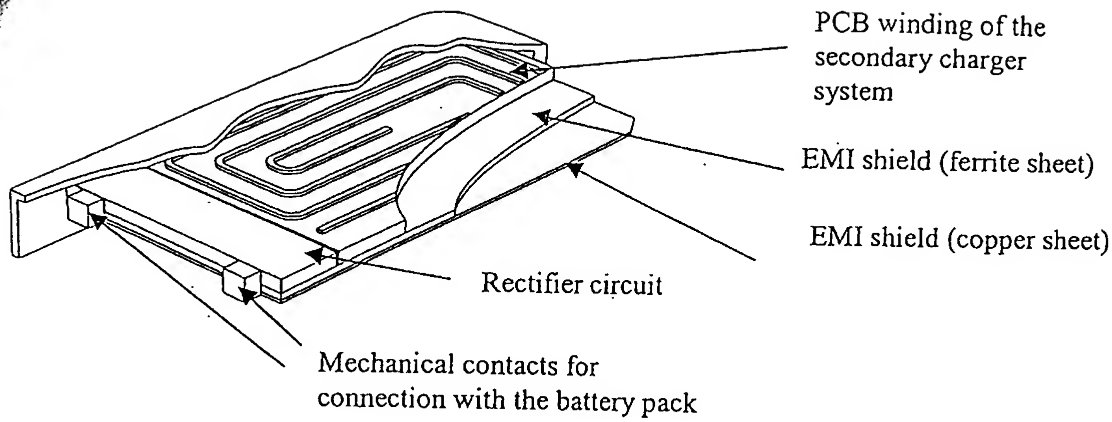

FIG.12(d)

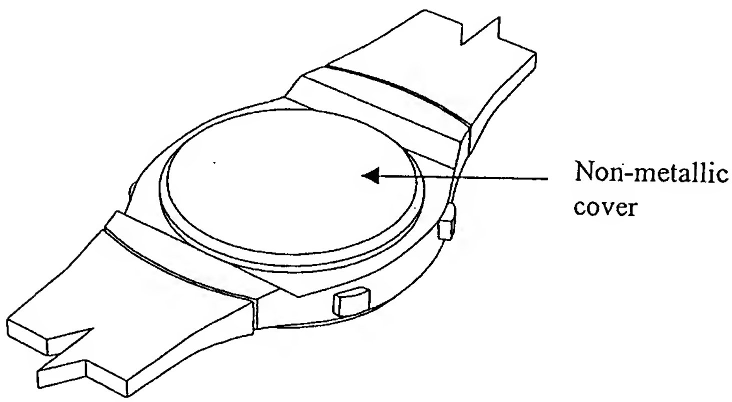

FIG13(a)

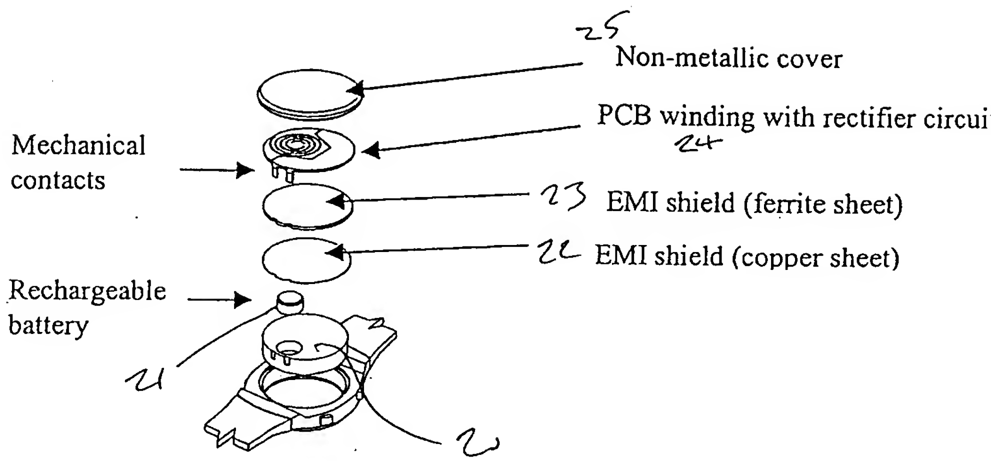
25
Non-metallic cover
PCB winding with rectifier circuit
24
Mechanical
contacts
23
EMI shield (ferrite sheet)
22
EMI shield (copper sheet)
Rechargeable
battery
21
2

FIG.13(b)

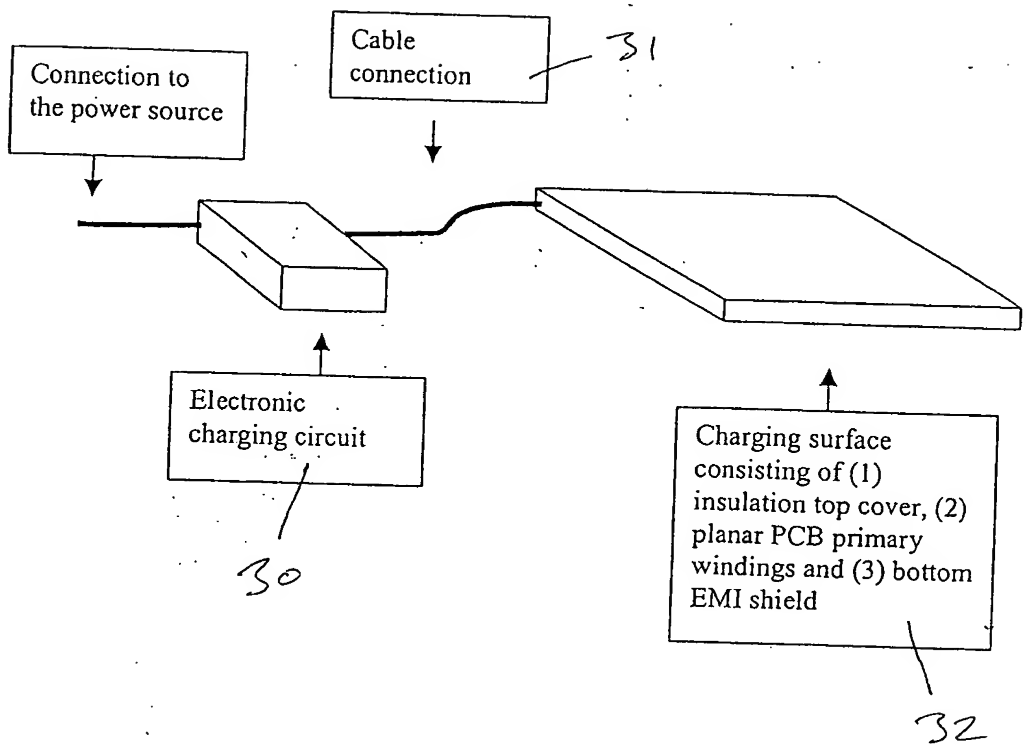
Connection to the power source
Cable connection
31
Electronic charging circuit
30
Charging surface consisting of (1) insulation top cover, (2) planar PCB primary windings and (3) bottom EMI shield
32

FIG. 14